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UTILITY PATENT APPLICATION TRANSMITTAL <i>(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))</i>	Attorney Docket No.	TITAN-55530
	First Inventor or Application Identifier	WILLIAM C. LINDSEY
	Title	SYSTEM FOR AND METHOD OF TRANSMITTING DATA FROM A TRANSMITTER TO A RECEIVER..
	Express Mail Label No.	EL589905091US

APPLICATION ELEMENTS <i>See MPEP chapter 600 concerning utility patent application contents.</i>	ADDRESS TO: Assistant Commissioner for Patents Box Patent Application Washington, DC 20231
1. <input checked="" type="checkbox"/> Fee Transmittal Form (e.g., PTO/SB/17) <i>(Submit an original and a duplicate for fee processing)</i>	5. <input type="checkbox"/> Microfiche Computer Program (Appendix)
2. <input checked="" type="checkbox"/> Specification [Total Pages 28] (preferred arrangement set forth below) - Descriptive title of the Invention - Cross References to Related Applications - Statement Regarding Fed sponsored R & D - Reference to Microfiche Appendix - Background of the Invention - Brief Summary of the Invention - Brief Description of the Drawings (if filed) - Detailed Description - Claim(s) - Abstract of the Disclosure	6. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary) a. <input type="checkbox"/> Computer Readable Copy b. <input type="checkbox"/> Paper Copy (identical to computer copy) c. <input type="checkbox"/> Statement verifying identity of above copies
3. <input checked="" type="checkbox"/> Drawing(s) (35 U.S.C. 113) [Total Sheets 7] 4. Oath or Declaration [Total Pages 3] a. <input checked="" type="checkbox"/> Newly executed (original or copy) b. <input type="checkbox"/> Copy from a prior application (37 C.F.R. § 1.63(d)) <i>(for continuation/divisional with Box 16 completed)</i> i. <input type="checkbox"/> DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).	ACCOMPANYING APPLICATION PARTS 7. <input checked="" type="checkbox"/> Assignment Papers (cover sheet & document(s)) 8. <input type="checkbox"/> 37 C.F.R. § 3.73(b) Statement of Power of Attorney (when there is an assignee) <input checked="" type="checkbox"/> 9. <input type="checkbox"/> English Translation Document (if applicable) 10. <input type="checkbox"/> Information Disclosure Statement (IDS)/PTO-1449 <input type="checkbox"/> Copies of IDS Citations 11. <input type="checkbox"/> Preliminary Amendment 12. <input checked="" type="checkbox"/> Return Receipt Postcard (MPEP 503) (Should be specifically itemized) * Small Entity 13. <input type="checkbox"/> Statement(s) filed in prior application, Status still proper and desired (PTO/SB/09-12) 14. <input type="checkbox"/> Certified Copy of Priority Document(s) (if foreign priority is claimed) 15. <input type="checkbox"/> Other:

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TOTAL AMOUNT OF PAYMENT (\$)**2522.00**

Complete if Known

Application Number	TO BE ASSIGNED
Filing Date	OCTOBER 13, 2000
First Named Inventor	WILLIAM C. LINDSEY
Examiner Name	TO BE ASSIGNED
Group / Art Unit	TO BE ASSIGNED
Attorney Docket No.	TITAN-55530

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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
101 690	201 345	Utility filing fee	710
106 310	206 155	Design filing fee	
107 480	207 240	Plant filing fee	
108 690	208 345	Reissue filing fee	
114 150	214 75	Provisional filing fee	

SUBTOTAL (1) (\$)**710**

2. EXTRA CLAIM FEES

Total Claims	Extra Claims	Fee from below	Fee Paid
74	-20** = 54	18	972
13	-3** = 10	80	800
Multiple Dependent			

**or number previously paid, if greater; For Reissues, see below

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
103 18	203 9	Claims in excess of 20	
102 78	202 39	Independent claims in excess of 3	
104 260	204 130	Multiple dependent claim, if not paid	
109 78	209 39	** Reissue independent claims over original patent	
110 18	210 9	** Reissue claims in excess of 20 and over original patent	

SUBTOTAL (2) (\$)**1772.00**

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
105 130	205 65	Surcharge - late filing fee or oath	
127 50	227 25	Surcharge - late provisional filing fee or cover sheet	
139 130	139 130	Non-English specification	
147 2,520	147 2,520	For filing a request for reexamination	
112 920*	112 920*	Requesting publication of SIR prior to Examiner action	
113 1,840*	113 1,840*	Requesting publication of SIR after Examiner action	
115 110	215 55	Extension for reply within first month	
116 380	216 190	Extension for reply within second month	
117 870	217 435	Extension for reply within third month	
118 1,360	218 680	Extension for reply within fourth month	
128 1,850	228 925	Extension for reply within fifth month	
119 300	219 150	Notice of Appeal	
120 300	220 150	Filing a brief in support of an appeal	
121 260	221 130	Request for oral hearing	
138 1,510	138 1,510	Petition to institute a public use proceeding	
140 110	240 55	Petition to revive - unavoidable	
141 1,210	241 605	Petition to revive - unintentional	
142 1,210	242 605	Utility issue fee (or reissue)	
143 430	243 215	Design issue fee	
144 580	244 290	Plant issue fee	
122 130	122 130	Petitions to the Commissioner	
123 50	123 50	Petitions related to provisional applications	
126 240	126 240	Submission of Information Disclosure Stmt	
581 40	581 40	Recording each patent assignment per property (times number of properties)	40.00
146 690	246 345	Filing a submission after final rejection (37 CFR § 1.129(a))	
149 690	249 345	For each additional invention to be examined (37 CFR § 1.129(b))	

Other fee (specify) _____

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APPLICATION

of

WILLIAM C. LINDSEY

and

YOUNG M. KIM

for

UNITED STATES LETTERS PATENT

on

**SYSTEM FOR, AND METHOD OF, TRANSMITTING DATA FROM A
TRANSMITTER TO A RECEIVER AND RECOVERING
THE DATA AT THE RECEIVER**

Docket No. TITAN-55530

[184641.1]

Sheets of Drawing Figures: Seven (7)

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EXPRESS MAIL NO. EL589905091US

This invention relates to systems for, and methods of, transmitting data from a transmitter to a receiver. The systems and methods of this invention provide for a transmission and reception of data with a greater accuracy than the systems and methods of the prior art.

BACKGROUND OF A PREFERRED EMBODIMENT OF THE INVENTION

5 In systems now in use, digital data is transmitted from a transmitter to a receiver. The digital data received at the receiver is not easily recognized. This results in part from noise produced in the transmission of the data from the transmitter to the receiver. It also results in part from the fact that the digital data travels in different paths from the transmitter to the receiver. For example, the digital data preferably travels directly from the transmitter to the receiver. However, the digital data can also travel from the transmitter to positions misaligned with the transmitter and the receiver and then travel from the misaligned positions to the receiver.

This misalignment causes the data received at the receiver from the misaligned position to be out of phase with the signals passing directly from the transmitter to the receiver. This out-of-phase relationship makes it difficult to recover the data at the receiver. The problem is aggravated because the receiver can often receive the same data from a number of different misaligned positions in addition to the data passing directly from the transmitter to the receiver. The misalignment can cause the data transmitted from the transmitter to the receiver to fade

because the phases of the misaligned signals are such that the amplitudes of the misaligned signals are subtracted from the amplitude of the signals translated directly from the transmitter to the receiver.

Attempts have been made to alleviate the problems of recovering data at the receiver when the data has been blurred by noise and by misalignments in phase. For example, in systems now in use for sending digital data from a controlled station (e.g., a transmitting station) to a controlling station (e.g., a receiving station), the digital data is provided with repetitive sequences of M modulations where M is a constant. Each of the M data modulations in each sequence is different from the other ones of the M modulations in the sequence. The M data modulations at the transmitter are provided in accordance with instructions from the controlling station (e.g. receiver). The modulated data is transmitted from the transmitter to the receiver in packets. In a first packet or sequence of packets, the data may be modulated with a first one of the M data modulations. In a second packet or sequence of packets, the data may be transmitted with a second one of the M data modulations. In a third one of the packets or sequence of packets, the data may be transmitted with a third one of the M data modulations.

In other systems now in use, the digital data in each packet or sequence of packets may be transmitted from the transmitter to the receiver at individual ones of N spreading codes. For example, the modulated data in a first one of the packets or sequence of packets may be

transmitted from the transmitter to the receiver at a first one of the N different spreading codes.

The data in a second one of the packets or sequence of packets may then be transmitted from the transmitter to the receiver at a second one of the N spreading codes rates. The data in a third one of the packets or sequence of packets may be subsequently transmitted from the transmitter to the receiver at a third one of the N spreading codes. Each spreading code may provide for a transmission of the data at a different rate. The N different spreading codes may be provided in accordance with instructions from the receiver.

The systems now in use and discussed in the previous paragraphs have reduced the problem of recovering data at a receiver, but have not solved the problem. It is still difficult to recover data at a receiver because of the proliferation in the reception at the receiver of out-of-phase data which clouds the reception and recovery of the in-phase data.

Several documents can be considered as prior art to the invention disclosed and claimed in this application. These are as follows:

- (a) U.S. Patent 5,541,955 issued on July 30, 1996, to Jacobsmeyer for an Adaptive Data Rate Modem;

- 5
- (b) An article published on pages 927-946 of the May, 1998, issue of IEEE Transaction on Information Theory. This article was written by Giuseppe Caire et al and was entitled "Bit-Interleaved Coded Modulation";
 - (c) An article published on pages 54-64 of the January, 2000, issue of IEEE Communications magazine. This article was written by Sanjiv Nanda et al and was entitled "Adaption Techniques in Wireless Packet Data Services";
 - (d) An article published on pages 2223-2230 of the July, 1995, issue of IEEE Transactions on Communications. This article was written by W. Webb and R. Steel and was entitled "Variable Rate QAM for Mobile Radio"; and
 - (e) An article published on pages 1218-1230 in the October, 1997, issue of IEEE Transactions on Communications. This article was written by A. Goldsmith and S. Chaa and was entitled "Variable-Rate Variable-Power MQAM for Fading Channels".
- 10

15 The prior art references specified above in paragraphs (a) through (e) disclose systems for modulating data and also disclose systems for providing spreading codes. However, they do not disclose systems for providing a combination of data modulations and spreading codes. They further do not disclose systems which provide channel encodings with either data modulations or spreading codes or both data modulations and spreading codes. There is also no disclosure in the prior art specified above of particular techniques of combining data modulations and spreading

codes to provide an optimal detection of the data even when the data is obscured by considerable amounts of multi-path fading.

BRIEF DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

5 Data at a transmitter is modulated, in accordance with instructions from a receiver, to provide M different modulations in successive sequences. N spreading codes are also provided in successive sequences at the transmitter, in accordance with instructions from the receiver, alternately with the M data modulations. The alternate sequences of the M data modulations and the N spreading codes are paired and individual ones of the M data modulations and the N spread codes in the paired sequences are combined (e.g. multiplied).

10 Alternatively, an individual one of the M data modulations is combined (e.g. multiplied) with an individual one of the N spreading codes in the adjacent sequence. The modulator and the spreader may be included at the transmitter with (a) a channel encoder which provides channel coding in accordance with instructions from the receiver, (b) a puncturer which removes particular data in accordance with instructions from the receiver and (c) an interleaver.

15 The paired combinations of the individual ones of the M data modulations and the spreading codes are transmitted to the receiver, which uses correlation or matched filter

techniques to recover each combination of the individual one of the data modulations and the individual one of the spreading codes. The recovered data is de-spread in accordance with instructions from the receiver, demodulated in accordance with instructions from the receiver and de-interleaved. The particular data punctured from the sequence is re-inserted and the data is
5 then decoded in accordance with the instructions from the receiver.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 is a schematic circuit diagram, primarily in block form, of one preferred embodiment of the invention for transmitting data in a particular format to a receiver;

Figure 2 is a schematic circuit diagram, primarily in block form, of another preferred embodiment of the invention for transmitting data in another format to a receiver;

Figure 3 is a schematic circuit diagram, primarily in block form, of a third preferred embodiment of the invention for transmitting data in still another format to a receiver, this preferred embodiment having advantages over the embodiment shown in Figures 1 and 2;

Figure 4 is a circuit diagram, primarily in block form, of a system constituting a preferred embodiment of the invention for receiving the data in the novel format from the transmitter shown in any of Figures 1-3 and for recovering the data;

Figure 5 is a circuit diagram, primarily in block form, of a system constituting another preferred embodiment of the invention for receiving the data in the novel format from the transmitter shown in any of Figures 1-3 and for recovering the data;

Figure 6 is a circuit diagram of an expanded system constituting a preferred embodiment of the invention, and preferably incorporating any of the systems shown in Figures 1-3, for transmitting data in any of the novel formats of Figures 1-3 to the receiver; and

Figure 7 is a circuit diagram of an expanded system constituting a preferred embodiment of the invention, and preferably incorporating either of the systems shown in Figures 4 and 5, for receiving the data in the novel format from the transmitter shown in Figure 6 and for recovering the data.

DETAILED DESCRIPTION OF A PREFERRED
EMBODIMENTS OF THE INVENTION

Figure 1 schematically illustrates a system, primarily in block form and constituting a preferred embodiment of the invention, for sending data in digital form in a particular format from a transmitter (generally indicated at 10) to a receiver. The transmitter 10 includes a bus 12 for providing data input in a binary form. A channel encoder 14 may convert each binary signal to a number of binary bits indicating the different channels in which the data is provided. The inclusion of the channel encoder 14 is preferable but not mandatory.

The binary signals in the channel encoder 14 are introduced to a mapper 16. The mapper 16 provides binary indications identifying each of the channels. For example, the paired binary indications 01 could represent an upper right quadrant. Alternatively, the paired binary indications 01 could represent a lower left quadrant. The inclusion of the mapper 16 is preferable but is not mandatory.

The signals from the mapper 16 are modulated by a modulator 18. The modulations may be in a number of different forms each known in the prior art. For example, the modulations may be in the form of quadrature amplitude modulation (QAM), quadrature phase shift keying (QPSK) or star quadrature amplitude modulations (SQAM). The QAM modulations may

illustratively be in 16QAM (where four (4) positions are provided in each of four (4) quadrants) or in 64 QAM (where sixteen (16) positions are provided in each of the four (4) quadrants).

A plurality of different modulations (e.g, M) are provided by the modulator 18. The M different modulations are produced respectively on a sequential basis of successive packets of digital signals. For example, a first modulation may be produced in a first packet or in a successive number of packets. A second modulation may then be produced in a second packet or in a successive number of packets. Successive modulations may be sequentially produced in successive packets, or successive numbers of packets, until the M different modulations are produced. Thereafter, the cycle of M successive modulations is repeated for the packets in successive sequences on a repetitive basis.

The signals from the bus 12, the channel encoder 14, the mapper 16 and the modulator 18 are in serial form. They are converted to a parallel form by a serial-to-parallel converter 20 in a manner well known in the prior art. The parallel signals from the converter 20 are introduced to a plurality of multiplier stages respectively designated as 22a, 22b...22n. Each of the multipliers 22a, 22b...22n also respectively receives an individual one of a plurality of N spreading code signals on an individual one of lines 24a, 24b...24n.

Each of the N spreading codes respectively provided on an individual one of the lines 24a...24n may be produced at a different rate from the rate produced by the other ones of the N spreading codes. Thus, the multiplier 22a may multiply the modulated data $S_1(t)$ and the spreading code $C_1(t)$ where S_1 represents the first one of the M different data modulations and $C_1(t)$ represents the first one of the N spreading codes. Similarly, the multiplier 22b may multiply the modulated data $S_2(t)$ and the spreading code $C_2(t)$. An adder 26 receives the outputs from the multipliers 22a, 22b...22n. An amplifier may be included in the adder 26.

The data modulations $S_1(t) \dots S_m(t)$ have a bandwidth indicated at 28 in Figure 1. The spreading code signals $C_1(t) \dots C_n(t)$ have a bandwidth 30 which may be considerably larger than the bandwidth 28. The increased bandwidth 30 is advantageous in that it decreases noise in the transmitted and received signals and decreases the disadvantageous effects of out-of-phase signals. The out-of-phase signals are particularly disadvantageous because they can decrease the magnitude of the signals transmitted directly from the transmitter to the receiver. This results from the fact that the phases of the out-of-phase signals may be directly opposite to the phase of the directly transmitted signal. Because of this, the increased bandwidth provided by the N spreading codes facilitates the recovery at the receiver of the in-phase data provided at the transmitter and transmitted directly to the receiver. The increased bandwidth is disadvantageous in that it slows the transmission of data from the transmitter to the receiver.

As will be disclosed in detail subsequently, it is known in the prior art to change one of the data modulations and the spreading codes without simultaneously changing the other one. However, it is not known in the prior art to change simultaneously the data modulations and spreading codes. Simultaneously changing both the data modulations and the spreading codes offers certain advantages. It strengthens the signals transmitted directly from the transmitter to the receiver against fading resulting from multi-path transmissions from the transmitter to the receiver. However, there is also a disadvantage. This may be seen from the relative bandwidths of the data modulations and the spreading codes. The data modulations have a bandwidth indicated at 28 in Figure 1 and the spreading codes have a bandwidth indicated at 30. As will be seen, the bandwidth 30 is significantly greater than the bandwidth 28. The increased bandwidth 30 facilitates the recovery of the data transmitted from the transmitter directly to the receiver from the fading resulting from multi-path passages of the data from the transmitter to the receiver. However, the increased range of the bandwidth 30 slows the transmission of data from the transmitter to the receiver.

Figure 2 schematically shows another system, primarily in block form, for sending data in a particular format from a transmitter, generally indicated at 30, to a receiver. The system 30 is designated as a single code system because there is only a single spreading code $C_1(t)$. This causes the rate of the orthogonal signals generated by the spreading code to be fixed. In this system, the number of different rates for the transmission of the data modulations is increased.

The transmitter shown in Figure 2 may include a channel encoder 14a corresponding to the channel encoder 14, a mapper 16a corresponding to the mapper 16, a modulator 18a corresponding to the modulator 18 and a serial-to-digital converter 20a corresponding to the serial-to-parallel converter 20. The parallel output from the converter 20 is introduced on a bus 32 to a multiplier 34 which also receives the spreading code $C_1(t)$. The transmitter shown in Figure 2 distinguishes over the prior art in providing for simultaneous changes in the data modulations and the spreading code.

Figure 3 schematically illustrates a preferred embodiment of a transmitter, generally indicated at 40, of the invention. The transmitter 40 is primarily in block form and is preferred to the embodiments shown in Figures 1 and 2. The transmitter 40 includes a channel encoder 42, a mapper 44, a modulator 46 and a serial-to-parallel converter 48 respectively corresponding to the channel encoder 14, the mapper 16, the modulator 18 and the serial-to-parallel converter 20 in Figure 1.

In the system shown in Figure 3, assume that there are three (3) different data modulations and that there are five (5) different spreading codes. Under these circumstances, M would be 3 and N would be 5. The M data modulations are provided at the transmitter 40 in accordance with instructions from the receiver. In like manner, the N spreading codes are provided at the transmitter 40 in accordance with instructions from the receiver.

As shown in Figure 3, the three (3) data modulations are initially presented in a sequence as represented by the numerals 1, 2, 3 and the five (5) spreading codes are then presented in a sequence as represented by the numerals 4, 5, 6, 7, 8. The three (3) data modulations are then presented again in a sequence as represented by the numerals 9, 10, 11 and the five (5) spreading codes are again presented in a sequence as represented by the numerals 12, 13, 14, 15, 16.

Successive sequences of the data modulations and then the spreading codes are repeated in the manner specified above. It will be appreciated that a sequence of the successive spreading codes may be presented before a related sequence of the successive data modulation without departing from the scope of the invention.

The successive data modulations in a sequence are introduced from the serial-to-parallel converter 48 to a bus 50. This is indicated by the numerals 1, 2, 3 in a first column, and then by the numerals 9, 10, 11 in a second column, adjacent the bus 50 in Figure 3. In like manner, the successive spreading codes in a sequence are introduced from the serial-to-parallel converter 48 to a bus 52. This is indicated by the numerals 4, 5, 6, 7, 8 below the numbers 1, 2, 3 in the first column, and then by the numerals 12, 13, 14, 15 and 16 below the numbers 9, 10, 11 in the second column.

A selector 54 is provided for selecting one (1) of the M data modulations in each data modulation sequence and a selector 56 is provided for selecting one (1) of the N different

spreading codes in each spreading code sequence. The selections by the stages 54 and 56 are paired. In other words, the M data modulations indicated as 1, 2, 3 for a time $m=0$ are paired with the N spreading codes indicated at 4, 5, 6, 7, 8 for a time $m = 0$. In like manner, the M data modulations indicated as 9, 10, 11 for a time $m=1$ are paired with the spreading codes indicated as 12, 13, 14, 15, 16 for the time $m=1$. The selections of the individual one of the M data modulations in each sequence and the individual one of the N spreading codes in each sequence may be made in accordance with instructions from the receiver. The selected one of the M data modulations in each sequence and the selected one of the N spreading codes in each sequence are combined as in a multiplier 58 and are introduced to a bus 60 for transmission to the receiver.

In the transmitter 40,

$$\log_2 M = K_m, \text{ where} \quad (1)$$

$M =$ a constant; and

$K_m =$ a constant

In like manner,

$$\log_2 N = K_n, \text{ where} \quad (2)$$

$N =$ a constant; and

$K_n =$ a constant

Thus $K = K_m + K_n$, where (3)

$K = \text{a constant}$

K indicates the number of binary bits to be provided in the encoder 42 to indicate the number of different channels to be provided for the successive stages in the transmitter.

In Figure 3, b can be considered as the output from the channel encoder 42. Successive signals representing data modulations can be represented as

$b_1(m) = [b(mk), b(mk+1) \dots (b(mk + K_m - 1))]$, where

$m = \text{a symbol time index indicated successively as } 0, 1, 2, \text{ etc.}$ (4)

$b = \text{the output from the channel encoder 42;}$

$b_1 = \text{the data modulations;}$

$b_2(m) = [b(mk + K_m), b(mk + K_m + 1) \dots b(mk + k - 1)]$, where (5)

$b_2 = \text{the spreading codes.}$

The system shown in Figure 3 has certain important advantages over the systems of the prior art and even over the systems shown in Figures 1 and 2 of this application. The system is better able to provide a distinction at the receiver between the data transmitted directly from the transmitter 40 to the receiver and phase-shifted data which limits the ability of the receiver to

detect the in-phase signals from the transmitter. The system of Figure 3 provides this distinction between the data transmitted directly to the receiver from the transmitter and the phase-shifted signals by providing M data modulations and N spreading codes. The system of Figure 3 is also advantageous over the systems of Figures 1 and 2 because it is simpler than the systems shown in
5 Figures 1 and 2 in selecting, for combination, only an individual one of the M data modulations in each sequence and only an individual one of the N spreading codes in each sequence. The system of Figure 3 is also advantageous in that it simultaneously selects the individual one of the M data modulations in each sequence and the individual one of the N spreading codes in each sequence.

10 The modulated data from the transmitter is received at a preferred embodiment of a receiver generally indicated at 70 in Figure 4. The receiver 70 may be of a correlator type and is shown primarily in block form. In a correlator type, the modulated data received at the receiver is introduced to a plurality of stages and is processed in a particular manner in each of these stages. The stage with the strongest signal is presumed to indicate the modulated data
15 transmitted from the transmitter. It provides a correlation with the transmitted signal. This signal is then processed to recover the data in the modulated data transmitted to the receiver. A receiver of the correlator type is known in the art but not in the context or environment disclosed in this application and not with the combination of stages shown in Figure 4.

The signals are received at the receiver 70 on a bus 72. The signals on the bus 72 are introduced to multipliers 74a, 74b...74n. Each of the multipliers, 74a, 74b...74n receives an individual one of a plurality of spreading code signals $C_1(t)$, $C_2(t)$... $C_n(t)$ respectively on lines 75a, 75b...75n. The outputs of the multipliers 74a, 74b...74n are respectively introduced to individual ones of a plurality of integrators 76a, 76b...76n. Each of the integrators 76a, 76b...76n integrates the output of its associated multiplier from the time 0 to the time T. Thus, for example,

$$Z_1 = \int_0^T Q_1 dt, \text{ where} \quad (6)$$

Q_1 = the input to the integrator 76a; and

Z_1 = the output from the integrator 76a.

In like manner,

$$Z_n = \int_0^T Q_n dt, \text{ where}$$

where Q_n = the input to the integrator 76n; and

Z_n = the output of the integrator 76n.

The output from each of the integrators 76a, 76b...76n is partly real and partly imaginary. To convert the output of each of the integrators, 76a, 76b...76n to an entirely real number, the absolute value of each of the outputs is squared. This is indicated at 78 in Figure 4. For example, the squaring of the output from the integrator 76a may be indicated as $|Z_1|^2$ and the

5 squaring of the output from the integrator 76n may be indicated as $|Z_n|^2$. A comparison is then made in a comparator 80 of the magnitudes of the different outputs from the integrators after the different integrated outputs have been squared. The individual one of the integrators 76a, 76b...76n introducing integrated output to the squaring stage 78 and providing the output with the largest magnitude in the stage 78 is then selected by a microprocessor 81 in a selector 22 on the basis of this comparison. The selected one of the integrators 76a, 76b...76n is then de-spread as at 83 to recover the modulated data. The de-spread data is then demodulated as at 84 to recover the data. The data is then analyzed on the basis of the guide lines provided by the mapper 16 and the channel encoder 14 at the transmitter to determine the significance of the data. The despreader 83 and the demodulator 84 are known in the prior art but not in the combination shown in Figure 4 and not in the context or environment set forth in this application.

10
15 Figure 5 illustrates another preferred embodiment, generally indicated at 85, of a receiver. The receiver may be of a matched filter type and is shown primarily in block form. Since the receiver 85 receives from the transmitter information concerning various parameters such as individual ones of the M data modulations and individual ones of the N spreading codes, the receiver may include a plurality of filters each having characteristics matching the characteristics of a combination of an individual one of the M data modulations and an individual one of the N spreading codes. The plurality of matched filters are indicated at 86a, 86b...86n in Figure 5 and are shown as receiving through a bus 88 the signals from the transmitter.

Each of the filters 86a, 86.....86n also receives a signal corresponding to the output capable of being provided by an individual one of the combinations of an individual one of the M data modulations and an individual one of the N spreading codes. As previously indicated, the receiver 85 knows the M data modulations and the N spreading codes since the receiver instructs the transmitter to use these data modulations and spreading codes. Because of this, each of the filters 86a, 86b...86n is able to match the characteristics of an individual one of the transmitted signals.

For example, the matched filter 86a receives signals on a line 90a. One of these signals corresponds to a combination of $b(mk)$ and $b(mk + km)$. The filter 86a passes the signal constituting the combination of $b(mk)$ and $b(mk + km)$ because of the matching characteristics of the filter with the signal provided on the line 90a. Similarly, the matched filter 86b receives signals on a line 90b. One of the signals may correspond to a combination of $b(mk + 1)$ and $b(mk + km + 1)$. When the signal received from the transmitter constitutes a combination of $b(mk + 1)$ and $b(mk + km + 1)$, the filter 86b passes the signal because of the matching characteristics of this filter with the signal provided on the line 90b. The magnitudes of the signals passing through the matched filters 86a, 86b...86n are compared in a comparator 88. A microprocessor 90 receives the signals from the comparator 88 and selects in a stage 92 the signals with the greatest magnitude from the matched filters 86a, 86b...86n. The signal passing through the selected one of the matched filters 86a....86n at each instant is despread in a

despreader 94 and demodulated in a demodulator 96 in a manner similar to that described for the embodiment shown in Figure 4.

Figure 6 shows a transmitter, generally indicated at 100, in a schematic block form. The transmitter 100 is included in a preferred embodiment of the invention. The transmitter 100 can include features of the transmitter shown in any one of Figures 1-3 and described above. The data bits are introduced through a bus 102 to an encoder 104 for encoding channels. For example, the channel encoder may provide an encoding for K channels in accordance with equation (3) set forth above. The encoder 104 may be a convolutional or turbo type of encoder. Instructions on a line 105 from the receiver shown in Figure 7 determine the encoding of the channels. A channel encoder corresponding to the channel encoder 104 is known in the prior art but not in the combination shown in Figure 6 and not for the purposes set forth in this application.

The output from the channel encoder 104 passes to a puncturer 106. A puncturer corresponding to the puncturer 106 is known in the prior art but not for purposes set forth in this application and not in the combination shown in Figure 6. The puncturer 106 deletes some of the output from the channel encoder 104 to provide for the transmission of data at an efficient and effective code rate. When the code rate of the encoder 104 is $R_c = k/n$ and l coded bits are punctured out of each (n) (P) coded bits, the effective code rate is $R_c = (KP) / (nP-1)$. The

puncturing may be provided at the transmitter in accordance with instructions from the receiver. The instructions may be provided through a bus 108. In the above equation, K is derived from equation (3).

After puncturing, the coded bits are interleaved as at 110. Interleaving is known in the prior art. The interleaved bits are then mapped into an individual one of the modulation symbols in the selected modulation scheme. This may be provided in accordance with the system shown in Figure 3 and described above. In mapping the interleaved output bits, Gray labeling may be used. The interleaved data is then modulated as at 114. The data modulations may be provided in accordance with instructions from the receiver. The data modulations may be provided through the bus 108.

The data modulation may consist of M subsets which are orthogonal to one another and each subset may have V original points. The modulation may be selected from a number of different modes including QPSK, QAM and SQAM. The selection of the puncturing and modulation schemes is based upon the channel condition information fed back by the receiver and other sources (for example, other base stations in the cellular radio system). Each modulation symbol may be produced at a rate R_s with a period of $T_s = 1/R_s$. Each modulation may be spread by a spreader 116 such as the spreader shown in Figure 3 and described above.

The spreading may be by an orthogonal sequence of a length N_c . The spreading code may be provided through a bus 118. The output from the spreader 116 is provided on a bus 120.

Each modulation symbol may be spread by an orthogonal sequence of a length N_c . The chip rate R_{chip} has a fixed value $(N_c)(K_s)$ to provide the transmitted signal with a substantially constant bandwidth. The maximum length of the spreading sequence may be denoted as N_c , max. Thus, the data rate R_D is

$$R_b = (R_{ce}) \log_2 (LM) (R_{chip})/N_c$$

$$R_b = (R_{cc}) \log_2 (VM) R_{chip}/N_c$$

The determination of the spread factor (N_c) of the spread code is based upon the delay spread observed at the receiver. (N_c) is chosen to be sufficiently large to avoid inter-symbol interference (ISI) caused by the delay spread of the multipath fading channel. As previously described, multipath fading channels occur when the data transmitted from the transmitter to the receiver also reaches the receiver through paths other than directly from the transmitter to the receiver. These indirect paths can produce inter-symbol interference (ISI) and can cause fading of the data transmitted directly from the transmitter to the receiver.

Although the individual ones of the stages shown in Figure 6 are known in the prior art, the combination of the stages shown in Figure 6 is not believed to be known in the prior art. Furthermore, the combination of stages shown in Figure 3 and described above is not believed to

be known in the prior art. This is particularly true when the combination of stages shown in Figure is used as the modulator 114 and the spreader 116 in Figure 6. The combination of stages shown in Figures 1 and 2 can also be used as the modulator 114 and the spreader 116 in Figure 6. In addition, although the puncturer 106 and the interleaver 108 provide advantages in the construction and operation of the transmitter 100 shown in Figure 6, they can be removed from the transmitter without departing from the scope of the invention.

Figure 7 is a schematic block diagram of a receiver, generally indicated at 120, which can be used with the transmitter 100 shown in Figure 6. The signals received by the receiver 120 are introduced to a bus 122 which is connected to a despreader 124. The construction of a despreader such as the despreader 124 is known in the prior art but not in the combination as shown in Figure 7 and not for the purposes set forth in this application. The despreader 124 eliminates the effects of the spread codes introduced to the modulated data at the transmitter such as the spreader 116 in Figure 6. The despreader 124 may operate in accordance with the instructions introduced from the receiver to the spreader 116 in Figure 6.

The signals on the bus 122 are also introduced to a channel estimator 126 which estimates the characteristics of the channel in which the signals have been transmitted to the receiver. For example, the channel estimator 126 may operate in accordance with the value K, the number of channels specified in accordance with equation (3) specified above. The signals from the

channel estimator 126 pass to lines 128 and 130. The line 128 provides the index for the spreading provided by the spreader 116 in Figure 6. The line 130 provides the index for the data modulations provided by the data modulator 114 in Figure 6.

After the received signals have been despread by the despreader 124, the modulations in the data are then removed in a demodulator 132. The demodulator 132 eliminates the modulations in the data in accordance with the instructions introduced from the receiver to the data modulator 114 in Figure 6. The demodulated data may then be introduced to a metric computer 134 which processes the data into a metric form and introduces the processed data to a deinterleaver 136.

The deinterleaver 136 restores the data to the form in which it existed before it was introduced to the puncturer 106 in Figure 6. A stage 138 designated as erasure inserter in Figure 7 restores the data to the form in which it existed before it was introduced to the puncturer 106 in Figure 6. A decoder 140 in Figure 7 restores the data to the form in which it was introduced to the channel encoder 104 in Figure 6.

Individual ones of the despreader 124, the demodulator 132, the metric computer 134, the deinterleaver 136, the erasure insertion stage 138 and the decoder 140 are known in the prior art but the combination shown in Figure 7 is not believed to be known in the prior art. Furthermore,

the combination is not known in the prior art for the purposes set forth in this application. When the puncturer 106 and/or the interleaver 108 are not included in the transmitter shown in Figure 6, the deinterleaver 136 and/or the erasure insertion stage 138 will not be included in the receiver shown in Figure 7.

5 Assume that a block or packet of data spans a time duration of T_B and that the block or packet of data is transmitted by the transmitter 100 to the receiver 120 at successive instants of time. Assume also that the time interval between consecutive transmitted blocks or packets is T_{FD} . The time interval T_{FD} may correspond to the delay in the feedback from the receiver 120 to the transmitter 100 of information relating to the channel conditions. As previously indicated, the signal received by the receiver 120 from the transmitter 100 are processed to decode the transmitted data bits and recover the transmitted data. The received signal is also used to estimate the local average of the channel conditions. The term "local average" is intended to mean that averaging is provided over the time span of T_B , the duration of a block or packet of data.

15 The relative speed between the movements of the transmitter 100 and the receiver 120 helps to determine the dynamics of the channel conditions. At a low speed of relative movements between the transmitter 100 and the receiver 120, the channel condition can be almost constant over a time duration of T_B or even over a multiple number of time durations of

T_B . At a high speed of relative movements between the transmitter 100 and the receiver 120, the channel condition can fluctuate many times over a wide range of values over the same time period of T_B or a multiple number of time durations of T_B .

The characteristics of the time-varying multipath fading channels include the local
5 average of signal-to-noise ratio (SNR), where noise represents all of the components other than the desired signal, delay spread and variability of the desired signal amplitude level among other things. The amount of the delay spread determines the level of inter-symbol interference (ISI)
10 and cross interference between the transmitted orthogonal signal components. In the preferred embodiments of this invention, increasing the spreading factor can reduce the level of the inter-symbol interference (ISI). Furthermore, it also enhances the capability of suppressing interference of the transmitted spread spectrum signal and helps to maintain the orthogonality between the transmitted signals. It also has an effect of lengthening the duration of the modulation symbols. Spreading factor can be defined as the ratio between the chip rate of the spreading codes and the rate of the data modulations.

15 Thus, depending upon the level of the delay spread observed in the spreading codes, the spreading factor is selected to provide sufficient protection against the inter-symbol interference (ISI) and against the cross interference. This will simplify the processing complexity of the receiver signal by avoiding equalization or other techniques of interference suppression.

Assuming that the spreading factor selected is sufficiently large to suppress the delay spread efforts of the multipath fading channel, the channel characteristic observed at the receiver 120 after despreading can be modeled by a flat fading channel. The performance at the receiver will accordingly depend upon the local average signal-to-noise ratio (SNR) and the variance of the
5 desired signal level. The optimal combination of code rate (or puncturing) and the scheme of the data modulations is determined based upon the two (2) aspects of the channel characteristics.

This invention provides for a combination of a channel code rate, data modulation and spreading code. This combination is provided to enhance the spectral efficiency achievable even with the deteriorations resulting from multipath fading channels. A set of orthogonal spreading
10 sequences may be used for spreading, and a determination of the spreading factor (or processing gain) is made based upon the channel impulse response to provide sufficient protection against the channel effects, such as delay spread, of multipath fading.

Different channel code rates may be obtained by puncturing simple basic convolutional or turbo code so that a single decoder can be used for different combinations of code rate and data
15 modulation. After selecting the spreading factor, channel code rate and data modulation are determined based on local average channel conditions instead of instantaneous channel conditions. Then the number of orthogonal spreading sequences is determined based on the user's data rate specification.

By selecting spreading factor, code rate and data modulation, targeted data rate can be achieved by using a minimal amount of radio resources under time-varying channel conditions. In adapting spreading factor, code rate and data modulation, it is important to realize that feedback delay in having the receiver inform the transmitter of channel conditions will be unavoidable. Because of this, it is important to realize that adaption by the system shown in Figures 6 and 7 should be based upon local average channel conditions. This provides for a successful adaptation by the system shown in Figures 6 and 7. It should also be appreciated that the system should also be based upon local average channel conditions when the transmitter 100 shown in Figure 6 is adapted to incorporate any of the systems shown in Figures 1-3 and/or when the receiver 120 shown in Figure 2 is adapted to incorporate either of the systems shown in Figures 4 and 5.

Solely relying on either one of the two (2) techniques of data modulation and spreading code to provide communication services at high data rates will cause the system to be inefficient or make the modem implementation inordinately complicated. By combining channel encoding, direct sequence spreading and adaptive coded modulation, high data rate wireless communication services can be provided reliably and efficiently.

Although this invention has been disclosed and illustrated with reference to particular embodiments, the principles involved are susceptible for use in numerous other embodiments

which will be apparent to persons of ordinary skill in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method of transmitting data from a transmitter to a receiver, including the steps of:

providing successive sequences of a plurality of modulation symbols for the data,

providing successive sequences of a plurality of spreading codes for the data ,

5 each individual one of the sequences of the spreading codes for the data being juxtaposed to an individual one of the sequences of the modulations for the data,

providing a parallel presentation of each individual one of the sequences of modulations for the data and the juxtaposed one of the sequences of spreading codes for the data, and

10 selecting an individual one of the modulations for the data in each sequence and an individual one of the spreading codes in the juxtaposed sequence for the data.

2. A method as set forth in claim 1, including the step of

combining the selected one of the modulations for the data in each sequence and the selected one of the spreading codes for the data in the juxtaposed sequence.

3. A method as set forth in claim 2, including the step of:

transmitting to the receiver the combination of the selected one of the modulations for the

data in each sequence and the selected one of the spreading codes for the data in the juxtaposed sequence.

4. A method as set forth in claim 3 wherein
the modulations are selected from a group consisting of QAM, SQAM and QPSK and
wherein
the spreading codes in each sequence are at different rates.

5. A method as set forth in claim 2 wherein
the combination of the selected one of the modulations in each sequence and the selected
one of the spreading codes in the juxtaposed sequence constitutes the product of the selected one
of the modulations and the selected one of the spreading codes.

6. A method of transmitting information data from a transmitter to a receiver,
including the steps of:

providing input signals,

mapping the input signals with a number of binary bits,

modulating the input signals from the mapper with sequences of M modulations,

providing spreading code sequences each having N spreading codes,

the number of binary bits in the mapper providing for a number of different values at least

equal to the product of M and N, and

selecting one of the M modulations in each modulation sequence and one of the N

10 spreading codes in each spreading code sequence.

7. A method as set forth in claim 6, including the step of:

combining the selected one of the M modulations in each modulation sequence and the
selected one of the N spreading codes in each spreading code sequence.

8. A method as set forth in claim 6, including the steps of:

multiplying the selected one of the M modulations in each modulation sequence and the
selected one of the N spreading factors in each spreading code sequence, and
transmitting the multiplied signals in each sequence to the receiver.

9. A method as set forth in claim 6, including the steps of:

providing alternate ones of the sequences of the M modulations and the sequences of the
N spreading codes,

presenting in parallel the M modulations in each modulation sequence and the N

5 spreading codes in the alternate one of the spreading code sequences, and

selecting one of the M modulations and one of the N spreading codes in each parallel
presentation.

10. A method as set forth in claim 9, including the steps of:

multiplying the selected one of the M modulations and the selected one of the N

10 spreading factors in each parallel presentation, and

transmitting to the receiver the combination of the selected one of the M modulations and
the selected one of the N spreading codes in each parallel presentation.

11. A method as set forth in claim 10 wherein

the M modulations are selected from a group consisting of QAM, SQAM and QPSK
modulations and wherein

the N spreading codes in each sequence are at different rates.

12. A method of transmitting information data from a transmitter to a receiver,
including the steps of:

providing a channel encoding of the information data,

providing a mapping of the channel encoded data,

5 providing a plurality of modulations of the mapped data,

providing a plurality of spreading codes,

selecting an individual one of the modulations and an individual one of the spreading
codes,

combining the selected one of the data modulations and the selected one of the spreading

10 codes, and

transmitting the combination of the selected one of the data modulations and the individual one of the spreading codes to the receiver.

13. A method as set forth in claim 12 wherein

the data modulations in the plurality are produced in a sequence and the spreading codes in the plurality are produced in a sequence and wherein

sequences of the data modulations and sequences of the spreading codes are alternately provided and wherein

individual sequences of the data modulations and the alternately provided sequences of the spreading codes are paired in parallel and wherein

an individual one of the data modulations and an individual one of the spreading codes in each parallel pair are selected for combination.

14. A method of transmitting and receiving modulated data, including the steps of:

providing data modulations in sequences each having M different data modulations,

providing spreading codes in sequences each having N different spreading codes, the

sequences of the N spreading codes being provided alternately with the sequences of the M data modulations,

selecting an individual one of the M data modulations values in each sequence of the data

modulations,

selecting an individual one of the N spreading codes in each spreading code sequence,

and

10 combining the selected one of the M values in each sequence of the data modulations and the selected one of the N spreading codes in the next alternate of the sequences of the spreading codes.

15. A method as set forth in claim 14 wherein

the combination of the selected one of the M data modulations in each sequence of the data modulations and the selected one of the N spreading codes in the alternate one of the spreading code sequences is transmitted from the transmitter to the receiver.

16. A method as set forth in claim 14, including the steps of:

providing at the receiver stages for receiving successive combinations of the selected one of the M different data modulations in each data modulations sequence and the selected one of the N different spreading codes in each alternate sequence of the spreading codes, and

5 introducing to the receiver stages the received combinations of the selected one of the M data modulations values in each sequence of the data modulations and the selected one of the N spreading codes in each alternate sequence of the spreading codes to obtain an identification of the received combinations.

17. A method as set forth in claim 16, including the step of:
demodulating the data modulations in each received combination after the identification of the received combination.

18. A method as set forth in claim 16, the step of:
despreading the spreading code in each received combination after the identification of the received combination.

19. A method as set forth in claim 16 wherein
each combination of the data modulation and the spreading code is subjected to
correlation factors to identify the combination and wherein
the spreading code in each received combination is despread after the identification of the
received combination and wherein
each received combination of the modulated data and the spreading code is demodulated
after being despread.

20. A method as set forth in claim 18 wherein
each combination of the selected data modulation and the selected spreading code is
passed through a plurality of matching filters, each having individual characteristics, to identify
the characteristics of the combination in accordance with the characteristics of the filter through

5 which the combination passes and wherein

the spreading code in each received combination is despread after the identification of the combination and wherein

each received combination of the data modulation and the spreading code is demodulated after being despread.

21. In a method of receiving and processing data from a transmitter, the steps of:

receiving at a receiver signals transmitted from the transmitter and constituting a combination of a selected one of M data modulations in a data modulation sequence and a selected one of N spreading codes in a spreading code sequence,

5 identifying, from the different combinations of the M available data modulations in the data modulation sequence and the N available spreading codes in the spreading code sequence, the selected one of the M data modulations in the data modulation sequence and the selected one of the N spreading codes in the spreading code sequence, and

despreading and demodulating the combination of the selected one of the M data
10 modulations in the data modulation sequence and the selected one of the N spreading codes in the spreading code sequence.

22. In a method as set forth in claim 21 wherein
correlation techniques are used to identify, from the different ones of the M data
modulations in the data modulation sequence and the different ones of the N spreading codes in
the spreading code sequence, the combination of the selected one of the M data modulations in
the modulation sequence and the selected one of the N spreading codes in the spreading code
sequence.

23. In a method as set forth in claim 21 wherein
matched filter techniques are used to identify, from the different ones of the M data
modulations in the data modulation sequence and the different ones of the N spreading codes in
the spreading code sequence, the selected one of the M data modulations in the data modulation
sequence and the selected of the N spreading code in the spreading code sequence.

24. In a method as set forth in claim 22 wherein
in the correlation technique, the received data is multiplied by each individual one of the
N spreading codes and wherein
the individual ones of the products are integrated with time and wherein
the individual ones of the integrated products are squared and wherein

the combination of the selected one of the M data modulations in each data modulation data sequence and the selected one of the M spreading code in each spreading code sequence is identified by the highest value in the squaring of the integrated products.

25. A method of transmitting data from a transmitter to a receiver, including the steps of:

encoding data in accordance with instructions from the receiver,

puncturing the data in accordance with instructions from the receiver,

interleaving the punctured data,

modulating the interleaved punctured data in accordance with instructions from the receiver,

spreading the modulated interleaved punctured data by a particular spreading code in accordance with instructions from the receiver, and

transmitting to the receiver the modulated interleaved punctured data spread by the particular spreading code.

26. A method as set forth in claim 25 wherein

the modulations are in sequences with M data modulations in each modulation sequence and wherein

the spreading codes are in sequences each having N spreading codes and wherein
5 an individual one of the M modulations is selected in each data modulation sequence and
wherein

the spreading code sequences alternate with the modulation sequences and wherein
an individual one of the N spreading codes is selected in each spreading code sequence
and wherein

10 the selected one of the M data modulations in each modulated data sequence and the
selected one of the N spreading codes in each spreading code sequence are combined and
wherein

the combination of the selected one of the M data modulations in each data modulation
sequence and the selected one of the N spreading codes in each alternate spreading code
15 sequence are transmitted to the receiver.

27. A method as set forth in claim 26 wherein

the combination of the selected one of the M data modulations in each data modulation
sequence and the selected one of the N spreading codes in each alternate spreading code
sequence is provided by multiplying the selected one of the M data modulations and the selected
5 one of the N spreading codes.

28. A method as set forth in claim 26 wherein
the M data modulations in each data modulation sequence and the N spreading codes in
each alternate spreading code sequence are provided in parallel and wherein
the selected one of the M data modulations and the selected one of the N spreading codes
5 are selected with the M data modulations and the N spreading codes in parallel.

29. A method of transmitting data and receiving the data at a
receiver, including the steps of:
providing the data at the transmitter,
providing a sequence of M data modulations in accordance with instructions from the
5 receiver,
providing a sequence of N spreading codes in accordance with instructions from the
receiver,
alternately providing the sequences of the M data modulations and the sequences of the N
spreading codes,
10 pairing in parallel successive ones of the sequences of the M data modulations and the
alternate sequences of the N spreading codes,
selecting from each parallel pair an individual one of the M data modulations and an
individual one of the N spreading codes,

combining the selected one of the M data modulations and the selected one of the N
15 spreading codes in each parallel pair, and

transmitting to the receiver the combination of the selected one of the M data
modulations and the selected one of the N spreading codes in each parallel pair.

30. A method as set forth in claim 29, including the steps of
receiving at the receiver the combination of the selected one of the M data modulations
and the selected one of the N spreading codes in each parallel pair, and
identifying the combination of the selected one of the M data modulations and the
5 selected one of the N spreading codes in each parallel pair.

31. A method as set forth in claim 30, including the step of:
demodulating at the receiver the selected one of the M data modulations , in each
identified combination, in accordance with instructions from the receiver, to recover the data in
the combination.

32. A method as set forth in claim 30, including the step of:
despreading at the receiver the individual one of the N spreading codes in each identified
combination, in accordance with instructions from the receiver, to recover the data in the
combination.

33. A method as set forth in claim 29, including the step of:
encoding the data at the transmitter, in accordance with instructions from the receiver,
before the data is modulated.

34. A method as set forth in claim 30, including the steps of,
encoding the data at the transmitter, in accordance with instructions from the receiver,
before the data is modulated and is provided with the spreading code, and
decoding the received combination of the selected one of the M data modulations and the
selected one of the N spreading codes in each parallel pair after the demodulation and
despreading of the data.

35. A method as set forth in claim 29, including the step of:
puncturing the data at the transmitter, in accordance with instructions from the receiver,
before the data is modulated and provided with the spreading code.

36. A method as set forth in claim 29, including the step of:
puncturing the data at the transmitter, in accordance with instructions from the receiver,
to delete particular data before the data is modulated and provided with the spreading code, and
depuncturing the data at the receiver, in accordance with the instructions from the
receiver, to restore the data punctured at the transmitter.

37. A method as set forth in claim 30, including the steps of:

puncturing the data at the transmitter in accordance with instructions from the receiver, to delete particular data before the data is modulated and provided with a spreading code,

despreading at the receiver the identified combination in each parallel pair of the selected

one of the M data modulations and the selected one of the N spreading codes in each parallel pair,

demodulating at the receiver the despread data at the receiver, and

re-inserting at the receiver the punctured data into the demodulated data to recover the data.

38. A method as set forth in claim 29, including the steps of:

puncturing the data at the transmitter, in accordance with instructions from the receiver, before the data is modulated and provided with the spreading code, and

interleaving the punctured data at the transmitter before the data is modulated and

provided with the spreading code.

39. A method as set forth in claim 30, including the steps of;

puncturing the data at the transmitter, in accordance with instructions from the receiver, to delete particular data before the data is modulated and is provided with the spreading code,

interleaving the punctured data at the transmitter before the data is modulated and
5 provided with the spreading code and after the data is punctured,

de-interleaving the punctured data at the receiver after the selected one of the M data
modulations and the selected one of the M spreading codes in each parallel pair has been
identified,

re-inserting the punctured data, in accordance with the instructions from the receiver,
10 before the decoding of the data but after the de-interleaving of the data.

40. A method as set forth in claim 39, including the steps of:

despreading at the receiver the selected one of the N spreading codes in each identified
combination, in accordance with instructions from the receiver, to recover the data in the
combination, and

5 demodulating at the receiver the selected one of the M data modulations in each identified
combination, in accordance with instructions from the receiver, to recover the data in the
combination.

41. In a method of receiving and processing data from a transmitter, the steps of:

receiving at a receiver from the transmitter modulated interleaved punctured data, spread
by a particular spreading code, received by the receiver from the transmitter,

de-spreading the received data in accordance with instructions provided by the receiver to

5 the transmitter to obtain the spreading of the data at the transmitter,

demodulating the modulated data in accordance with instructions provided by the
receiver to the transmitter to modulate the data at the transmitter,

de-interleaving the demodulated data,

re-inserting the punctured data into the de-interleaved data in accordance with

10 instructions provided by the receiver to the transmitter to obtain the puncturing of the data at the
transmitter, and

decoding the data, after the re-insertion of the punctured data into the de-interleaved data
in accordance with instructions provided by the receiver to the transmitter, to recover the data.

42. In a method as set forth in claim 41 wherein the data received at the receiver from
the transmitter constitutes a combination of a selected one of M data modulations values in a data
modulation sequence and a selected one of N spreading codes in a spreading code sequence, the
step of:

5 identifying, from the M data modulations in each data modulation sequence and the N
spreading codes in each spreading code sequence, the selected one of the M data modulations in
the data modulation sequence and the selected one of the N spreading codes in the spreading
code sequence, the identification occurring before the demodulation and the de-spreading of the
received data.

43. In combination in apparatus for transmitting data from a transmitter to a receiver,
a bus for providing successive sequences of M data modulations and N spreading codes,
a converter for converting each of the successive sequences of the M data modulations
and the N spreading codes to a parallel presentation of the M data modulations in each sequence
5 and the N spreading codes in the juxtapose sequence,

a first selector for selecting an individual one of the M data modulations in each of the
parallel presentations,

a second selector for selecting an individual one of the N spreading codes in each of the
parallel presentations,

10 a multiplier for combining the individual one of the M data modulations in each parallel
presentation and the individual one of the N spreading codes in the parallel presentation,

a transmitter for transmitting the combination of the selected one of the M data
modulations and the selected one of the spreading codes in each of the parallel presentations.

44. In a combination as set forth in claim 43,

an encoder for encoding the successive sequences of the data before the modulation of the
data with the M modulations and before the spreading of the modulated data with the N
spreading codes,

5 the converter being responsive to successive coded sequences of the M data modulations and the N spread codes.

45. In a combination s set forth in claim 43,
an interleaver for interleaving the encoded data.

46. In a combination as set forth in claim 43,
the stage for puncturing the data in the successive sequences in accordance with
instructions from the receiver before the introduction of the M modulations and the N spreading
codes to the data.

47. In a combination as set forth in claim 43,
the M data modulations introduced to the converter in each sequence being provided in
accordance with instructions from the receiver,

the N spreading codes introduced to the receiver in each sequence being provided in
5 accordance with instructions from the receiver.

48. In a combination as set forth in claim 43,
a stage for interleaving the data in the successive sequences in accordance with
instructions from the receiver before the introduction of the M modulations and the N spread
codes to the data.

49. In a combination as set forth in claim 43,
the modulator modulating the data with sequences of M data modulations in accordance
with instructions from the receiver,

the code spreader spreading the data in accordance with sequences of N spreading codes
in accordance with instructions from the receiver,

the modulator and the code spreader being operative before the selecting operations
provided by the first and second selectors.

50. In a combination as set forth in claim 44,
a stage for puncturing the data in the successive sequences before the introduction of the
M modulations and the N spreading codes to the data,

a stage for interleaving the data in the successive sequences before the introduction of the
M modulations and the N spreading codes to the data,

a modulator for modulating the data with sequences of M modulations in accordance with
instructions from the receiver,

a code spreader for spreading the data in accordance with sequences of M spread codes in accordance with instructions from the receiver,

10 the modulator and the code spreader being operative before the selecting operations provided the first and second selectors, and

a transmitter for transmitting the combination of the selected one of the M data modulations and the selected one of the N spreading codes in each of the successive sequences.

51. Apparatus for transmitting data from a transmitter to a receiver, including, an encoder for providing coded channels identifying relative locations of the data, a modulator for providing sequences of M data modulations in accordance with instructions from the receiver,

5 a code spreader for providing sequences of N spreading codes in accordance with instructions from the receiver,

a converter for converting each of successive encoded sequences of the M modulated data and the juxtaposed sequence of the N spreading codes to a parallel relationship,

as first selector of an individual one of the M modulated data in each sequence,

10 a second selector of an individual one of the N spreading codes in the juxtaposed sequence, and

a stage for combining the selected one of the M data modulations in each sequence and the selected one of the N spreading codes in the juxtaposed sequence to produce resultant

signal, and

15 a stage for transmitting the resultant signal in each sequence to the receiver.

52. Apparatus as set forth in claim 51, including

a stage for removing particular ones of the data sequences, before the modulation of the data with the M data modulations and before the spreading of the data in accordance with the N spreading codes, in accordance with instructions from the receiver.

53. Apparatus as set forth in claim 51, including,

a stage for interleaving the data in the sequences before the modulation of the data with the M data modulations and before the spreading of the data in accordance with the N spreading codes.

54. Apparatus as set forth in claim 51, including,

a converter for converting the M data modulations in each sequence and the M spreading codes in the juxtaposed sequence to a parallel presentation,

the first and second selector, being operative after the conversion of the M data

5 modulations in each sequence and the conversion of the N spreading codes in the juxtaposed sequence to the parallel presentation.

55. Apparatus for providing a transmission of data from a transmitter to a receiver,
including

a bus for providing data,

10 a modulator for modulating the data with sequences of M data modulations, and
a spreader for spreading the modulated data with sequences of M spreading codes,
a converter for converting the M data modulations in each sequence and the N spreading
codes in the juxtaposed sequence to a parallel presentation,

15 a first selector for selecting an individual one of the M data modulations in each parallel
presentation,

a second selector for selecting an individual of the N spreading codes in each parallel ion,
and

a stage for combining the selected one of the data modulation in each parallel
presentation and the selected one of the N spreading codes in the parallel presentation.

56. Apparatus as set forth in claim 55 wherein

the M data modulations in each sequence are provided in accordance with instructions
from the receiver and wherein

the N spreading codes in each juxtaposed sequence are provided in accordance with
5 instructions from the receiver.

57. Apparatus as set forth in claim 55, including

a transmitter for transmitting to the receiver the combination of the selected one of the M data modulations and the selected one of the N spreading codes in each parallel presentation.

58. Apparatus as set forth in claim 55 wherein

a puncturer is provided to remove data in the sequences, before the modulation of the data with the M data modulations in each sequence and before the spreading of the data with the N spreading codes in the juxtaposed sequence, in accordance with instructions from the receiver.

59. Apparatus as set forth in claim 55 wherein

an encoder provides channel coding to the data in the sequences before the modulation of the data with the M modulations and before the spreading of the data with the N spreading codes.

60. Apparatus as set forth in claim 55 wherein

the M data modulations in each sequence are provided in accordance with instructions from the receiver and wherein

the N spreading codes in each sequence are provided in accordance with instructions from the receiver and wherein

a puncturer is provided to remove data in the sequences, before the modulation of the data in each sequence with the M data modulations and before the spreading of the data in the

juxtaposed sequence with the N spreading codes, in accordance with instructions from the receiver and wherein

10 an encoder provides channel coding to the data in the sequences before the modulation of the data in each sequence with the M data modulations and before the spreading of the data in the juxtaposed sequence with the N spreading codes.

61. Apparatus for receiving and processing data from a transmitter, including
a bus for receiving transmitted data representing a combination of an individual one of M data modulations in a sequence and N spreading codes in a sequence juxtaposed to the sequence of the M data modulations,

5 a plurality of filters disposed in a parallel relationship, each of the filters providing characteristics corresponding to a combination of a selective one of the M data modulations and a selective one of the N spreading codes and each operative to receive the data on the bus and to provide an output dependent upon the matching between the characteristics of the filter and the characteristics of the data on the bus, and

10 a comparator responsive to the output of the matched filters for comparing the magnitude of the outputs from the matched filters in the plurality to select the output with the highest magnitude.

62. Apparatus as set forth in claim 61 wherein the data has been spread by N spreading codes in accordance with instructions from the receiver; the apparatus including:
a de-spreader at the receiver for removing the spreading codes in the data.

63. Apparatus as set forth in claim 61 wherein the data has been modulated by M data modulations in accordance with instructions from the receiver, the apparatus including:
a demodulator at the receiver for removing the modulations in the data modulation.

64. Apparatus as set forth in claim 61 wherein the data has been punctured in a particular pattern at the transmitter, in accordance with instructions from the receiver, to eliminate portions of the data, the apparatus including:
a de-puncturer for restoring at the receiver the portions of the data eliminated at the transmitter.

65. Apparatus as set forth in claim 61 wherein the data has been interleaved at the transmitter,
the apparatus including
a de-interleaver for de-interleaving the data.

66. Apparatus as set forth in claim 61 wherein the data has been encoded at the transmitter to identify the channels in which the data is provided:

the apparatus including:

a decoder at the receiver for eliminating the channel coding.

67. Apparatus as set forth in claim 62 wherein the data has been modulated at the transmitter by M data modulations in accordance with instructions from the receiver and wherein the data has been interleaved at the transmitter and wherein the data has been punctured at the transmitter in accordance with instructions from the receiver,

a demodulator at the receiver for demodulating the M data modulations,

a de-interleaver at the receiver for de-interleaving the data,

a de-puncturer at the receiver for depuncturing the data, and

a decoder for at the receiver for decoding the encoded data.

68. Apparatus for receiving data from a transmitter, including

a bus for receiving transmitted data representing a combination of an individual one of M data modulations in a sequence and N spreading codes in a juxtaposed sequence,

a plurality of multipliers each constructed to combine the transmitted data and an

individual of the data codes to provide an output representative of the combination,

a plurality of integrators each operatively coupled to an individual one of the multipliers, to integrate over a particular period of time the output from an individual one of the multipliers,

a plurality of squaring stages each operatively coupled to an individual one of the integrators for squaring the output of the individual one of the integrators, and

10 a comparator responsive to the outputs of the squaring stages for selecting the individual one of the squaring stages with the largest output and operatively coupled to the integrators for selecting for its output the output of the individual one of the integrators operatively connected to the individual one of the squaring stages.

69. Apparatus as set forth in claim 68 wherein the data has been spread by N spreading codes in accordance with instructions from the receiver; the apparatus including:

a de-spreader for restoring the data to the form at the transmitter before the spreading at the transmitter by the N spreading codes.

70. Apparatus as set forth in claim 68 wherein the data has been modulated by M data modulations in accordance with instructions from the receiver, the apparatus including:

a demodulator for restoring the data to the form at the transmitter before the modulation at the transmitter by the M data modulations.

71. Apparatus as set forth in claim 68 wherein the data has been punctured in a particular pattern at the transmitter, in accordance with instructions from the receiver, to eliminate portions of the data, the apparatus including:

a de-puncturer for restoring at the receiver the portions of the data eliminated at the transmitter.

72. Apparatus as set forth in claim 68 wherein the data has been interleaved at the transmitter,

the apparatus including

a de-interleaver for returning the data at the receiver to the form at the transmitter before the interleaving of the data.

73. Apparatus as set forth in claim 62 wherein the data has been encoded at the transmitter to identify the channels in which the data appears:

the apparatus including:

a decoder for returning the data at the receiver to the form at the transmitter before the encoding of the data by the encoder.

74. Apparatus as set forth in claim 69 wherein the data has been modulated at the transmitter in accordance with instructions from the receiver and has been interleaved at the transmitter and has been punctured with a particular pattern at the transmitter, in accordance with instructions from the receiver, to eliminate portions of the data and has been encoded at the transmitter, in accordance with instructions from the receiver, to identify channels in which the data is provided, the apparatus including:

a demodulator at the receiver for restoring the data to the form at the transmitter before the modulation at the transmitter by the M data modulations,

a de-interleaver at the receiver for returning the data at the receiver to the form at the transmitter before the interleaving of the data,

a de-puncturer at the receiver for restoring at the receiver the portions of the data eliminated at the transmitter, and

a decoder for returning the data at the receiver to the form at the transmitter before the encoding of the data by the encoder.

ABSTRACT

Data at a transmitter is modulated, in accordance with instructions from a receiver, to provide M different modulations in successive sequences. N spreading codes are also provided in successive sequences at the transmitter, in accordance with instructions from the receiver, alternately with the M data modulations. The alternate sequences of the M data modulations and the N spreading codes are paired and individual ones of the M data modulations and the N spreading codes in the paired sequences are combined (e.g. multiplied). Alternatively, an individual one of the M data modulations is combined (e.g. multiplied) with an individual one of the N spreading codes in the adjacent sequence. The modulator and the spreader may be included at the transmitter with (a) a channel encoder which provides channel coding in accordance with instructions from the receiver, (b) a puncturer which removes particular data in accordance with instructions from the receiver and (c) an interleaver. The paired combinations of the individual ones of the M data modulations and the N spreading codes are transmitted to the receiver, which uses correlation or matched filter techniques to recover each combination of the individual one of the data modulations and the individual one of the spreading codes. The recovered data is de-spread in accordance with instructions from the receiver, demodulated in accordance with instructions from the receiver and de-interleaved. The particular data punctured from the sequence is re-inserted and the data is then decoded in accordance with the instructions from the receiver.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2
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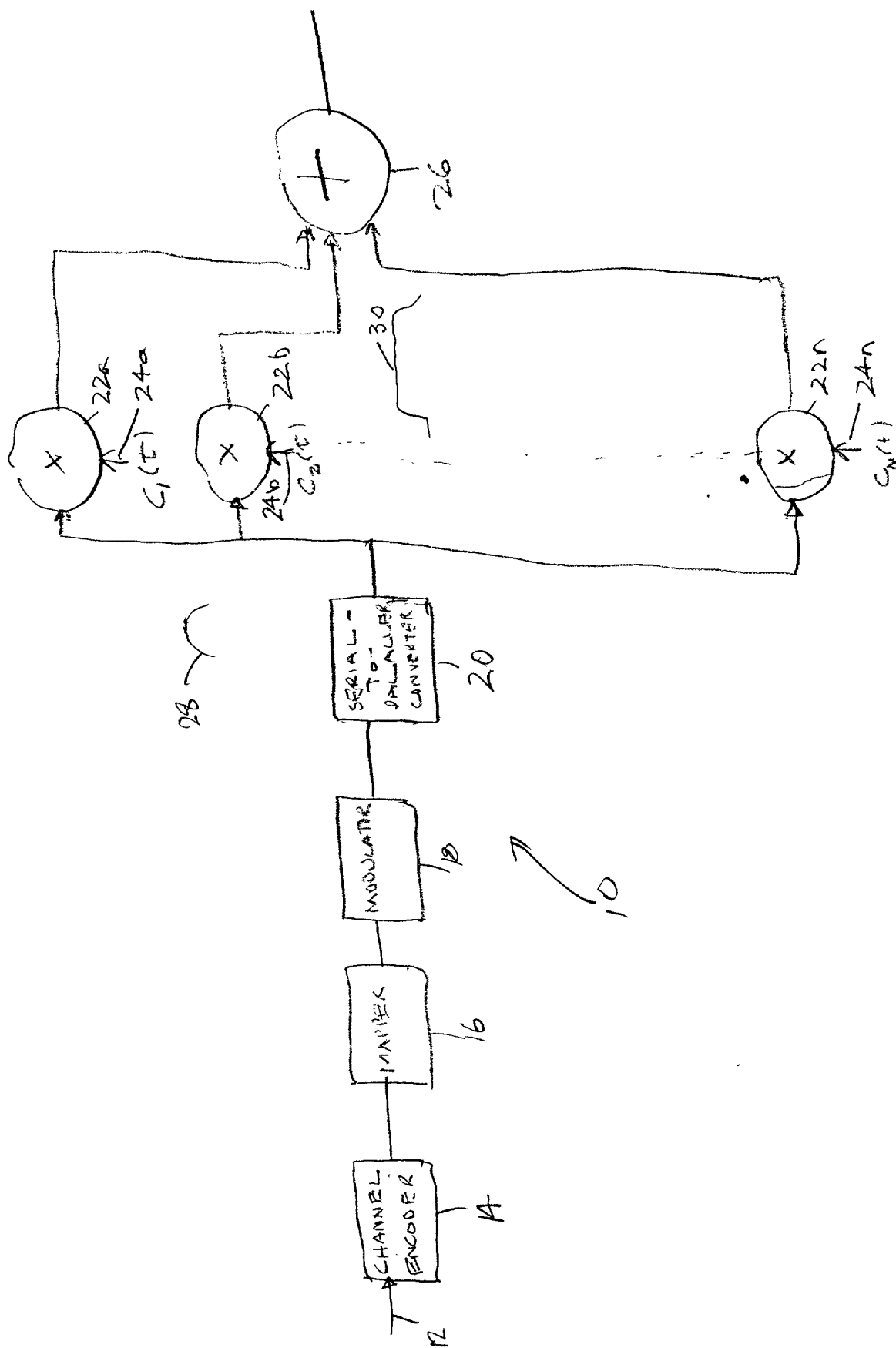


FIG. 1

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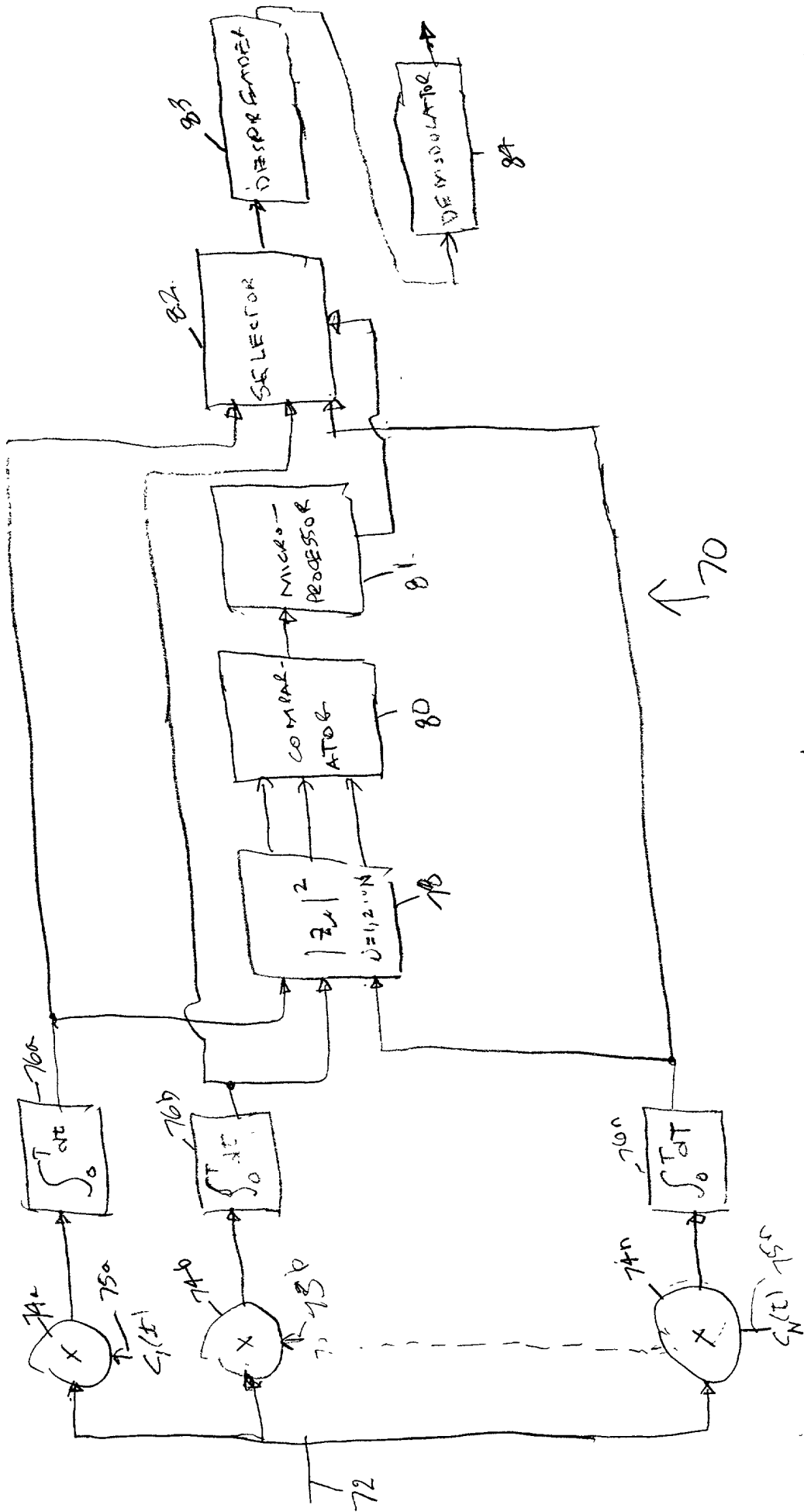
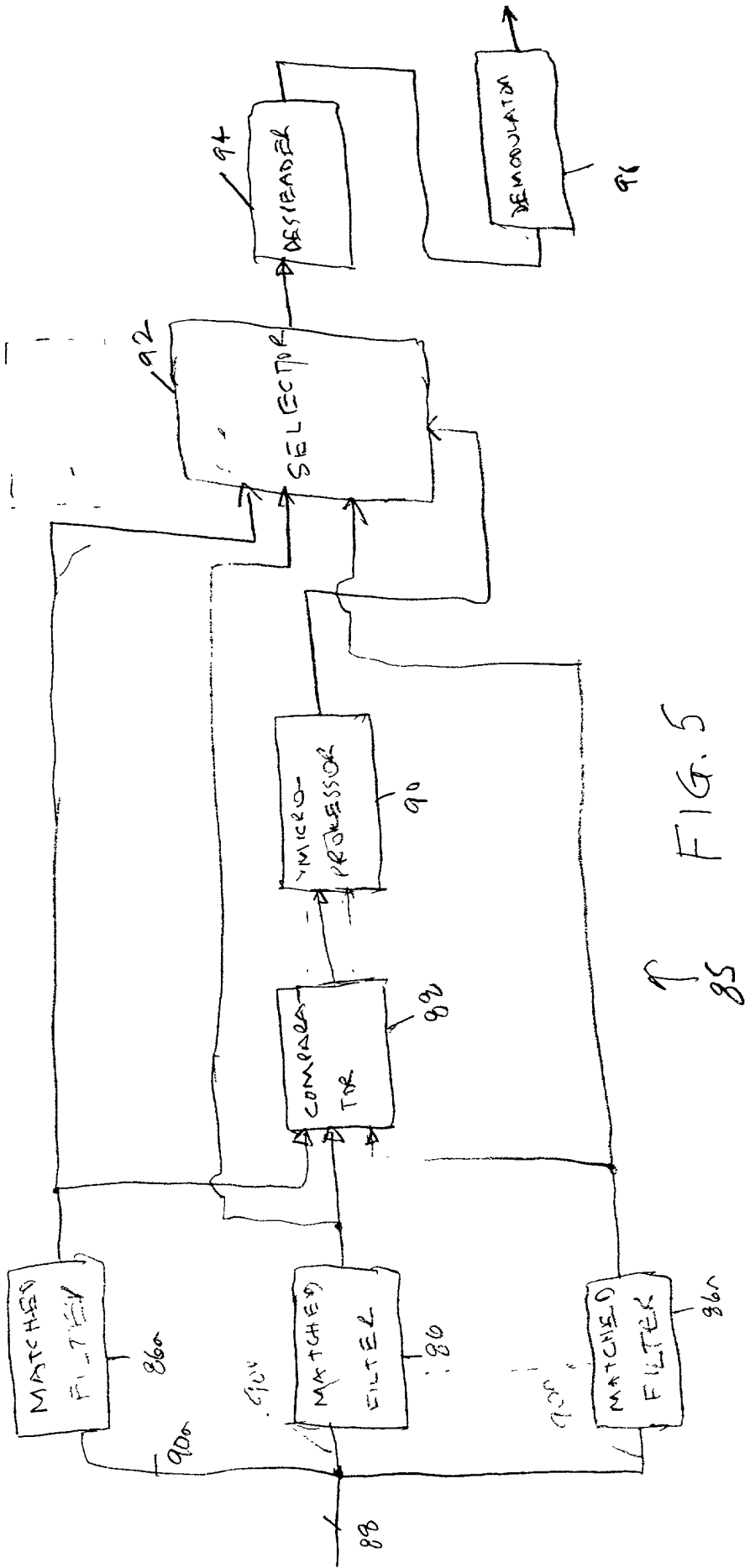


Fig. 4



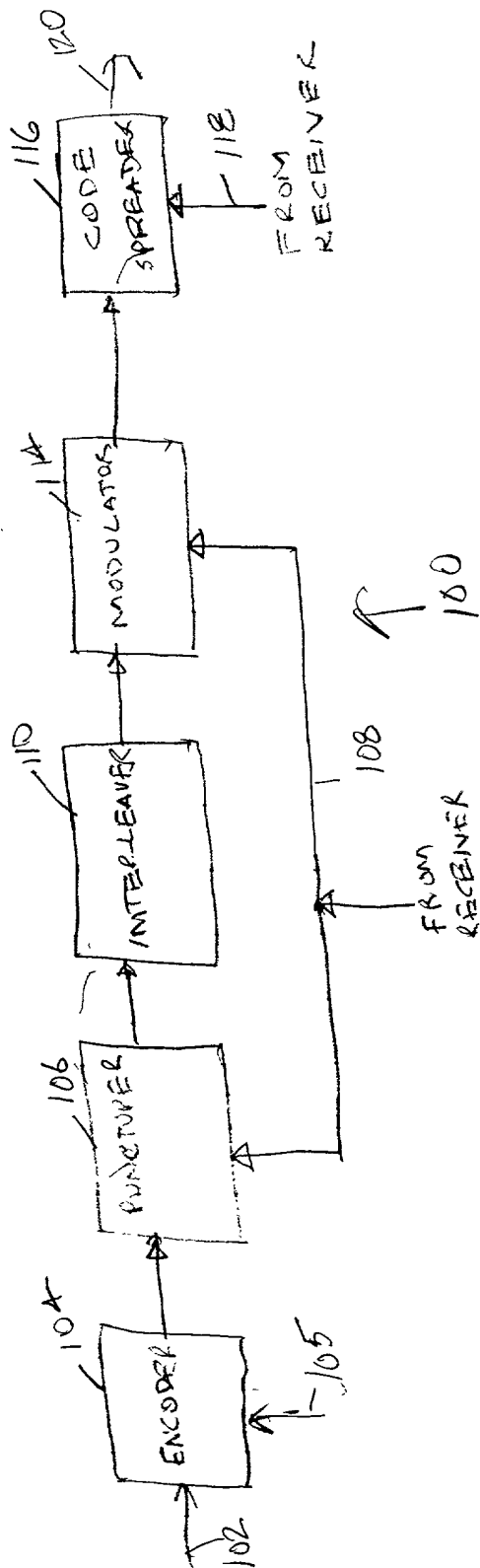


FIG. 6

DECLARATION AND POWER OF ATTORNEY

As the below named inventors, we hereby declare that:

Our residences, post office addresses and citizenships are as stated below next to our names.

We believe we are the original, first and joint inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled SYSTEM FOR, AND METHOD OF, TRANSMITTING DATA FROM A TRANSMITTER TO A RECEIVER AND RECOVERING THE DATA AT THE RECEIVER the specification of which (check one)

X is attached hereto

was filed on _____

As United States Application Number or PCT International Application
No. _____, and was amended on _____ (if applicable)

We hereby state that we have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above.

We acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. § 1.56.

We hereby claim foreign priority benefits under 35 U.S.C. § 119 (a) - (d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States,

listed below and have also identified below any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)		Priority Claimed	
Number	Country	Day/Mo./Yr. Filed	Yes No
_____	_____	_____	___ ___
_____	_____	_____	___ ___

We hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, we acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

_____	_____	_____
Appln. Serial No.	Filing Date	Status

We hereby appoint the following attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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